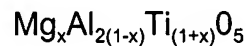


invention may be quite instructive. As set forth in dependent claim 5, the subject invention is directed to a sintered body of aluminum magnesium titanate obtained according to the process of claim 1. This latter claim recites a process for producing a sintered body comprising as a basic component aluminum magnesium titanate represented by the composition formula:

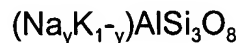


wherein the value of x is $0.1 < x < 1$,

the process comprising a step of sintering a formed product from a raw material mixture comprising the ingredients (i) and (ii) below:

(i) 100 parts by weight, calculated on an oxide basis, of a mixture comprising a Mg-containing compound, an Al-containing compound and a Ti-containing compound at the same metal component ratio as the metal component ratio of Mg, Al and Ti in the composition formula,

(ii) 1-10 parts by weight of an alkali feldspar represented by the composition formula:



wherein the value of y is $0 < y < 1$.

As is apparent from the above, the sintered body of aluminum magnesium titanate according to claim 5 is represented by the composition formula $\text{Mg}_x\text{Al}_{2(1-x)}\text{Ti}_{(1+x)}\text{O}_5$, wherein x is $0.1 < x < 1$.

Of particular significance is that the sintered body of aluminum magnesium titanate represented by the above composition formula has high mechanical strength and excellent thermal decomposition resistance, while maintaining the low coefficient of thermal expansion of aluminum magnesium titanate. Such a sintered body of aluminum magnesium titanate can be stably and continuously used at temperatures ranging from 800°C to 1280°C, at which conventional sintered bodies of aluminum titanate are not suitable, for long periods of time. In addition, the sintered body of aluminum magnesium titanate has excellent properties as a refractory, allowing the use thereof at high temperatures not less than 1500°C, at which magnesium titanate cannot be used. It is submitted that such a sintered body is not taught or suggested by the cited '863 Japanese patent publication cited in the outstanding Office Action.

More particularly, the '863 patent publication relates to a high strength and low thermal-expansion ceramic obtained by adding sumecton to aluminum titanate, and discloses that MgO, SiO₂ or the like can be added as an additive in addition to sumecton. The cited publication, however, does not disclose any range for the amount of sumecton and other additives which are added and merely shows an example of specific compositions in the Examples. To clarify the contents of the cited '863 Japanese patent publication, a complete English translation thereof is attached hereto.

As mentioned above, the '863 publication discloses specific compositions of sintered

products in the Examples. Specifically, sintered products are only set forth in samples Nos. 3 and 4 among the samples of Fig. 4 in the '863 publication. Samples Nos. 3 and 4 are prepared using a raw material comprising 90 wt% of aluminum titanate, 5 wt% of TiO_2 and 5 wt% of sumecton SA. This latter component sumecton SA contains, as shown in Fig. 3, Al_2O_3 and MgO as serving as raw materials for aluminum magnesium titanate, and the proportions of Al_2O_3 and MgO are 5 wt% and 30 wt%, respectively. Based on these proportions, the raw material composition of samples Nos. 3 and 4 of Fig. 4 is rewritten in terms of the proportions of Al_2TiO_5 , Al_2O_3 , TiO_2 and MgO serving as a raw material for aluminum magnesium titanate, which is shown in the following Table 1.

Table 1

	Raw material composition (wt%)				
	Al_2TiO_5	TiO_2	Al_2O_3	MgO	Others
	90	5	0.25	1.5	3.5
Note		Additive	MgO and Al_2O_3 in sumecton		Other ingredients in sumecton

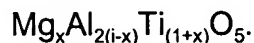
The following Table 2 shows the raw material composition of samples Nos. 3 and 4 of the '863 publication as calculated in terms of mol% when the total amount of Al_2TiO_5 , Al_2O_3 , TiO_2 and MgO is defined as 100%.

Table 2

Raw material composition (mol%)			
Al_2TiO_5	TiO_2	Al_2O_3	MgO
82.9	10.5	0.4	6.2

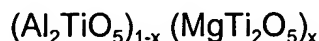
As set forth previously, the sintered body of aluminum magnesium titanate as

presently claimed is represented by the composition formula:



As is described on page 1, lines 8 to 11 of the subject specification, the sintered body of aluminum magnesium titanate is a solid solution which has complete solubility in the solid state throughout the entire composition region of aluminum titanate represented by Al_2TiO_5 and magnesium titanate represented by MgTi_2O_5 .

The composition formula recited in the subject claims can be rewritten by the formula:



in which aluminum titanate and magnesium titanate forming a solid solution are individually shown. If it is assumed that, in proportion to the molar ratio of Al_2O_3 and MgO shown in Table 2, Al_2O_3 and MgO individually react with TiO_2 to form Al_2TiO_5 and MgTi_2O_5 , and the excess Al_2O_3 and MgO do not dissolve into the aluminum magnesium titanate crystals, the proportions of Al_2TiO_5 and MgTi_2O_5 to be formed in the sintered body samples Nos. 3 and 4 of the '863 publication are 94.2 mol% and 5.8 mol%, respectively, when the total amount thereof is defined as 100 mol%. Thus, the value of x in the composition formula is 0.058.

As discussed above, even assuming that sintered bodies of aluminum magnesium titanate are formed in samples Nos. 3 and 4 in the Example of the '863 publication, the value of x in the composition formula is 0.058. In distinct contrast, the value of x in the

composition formula recited in claim 1 is $0 \leq x < 1$.

Thus, the value of x for the sintered body of the '863 publication is below the range specified in claim 1 of the present application. Therefore, it is submitted that the sintered body of the cited '863 publication is clearly different from the sintered body defined in claims 1 and 5 of the present application.

In order to further clarify the differences between the sintered bodies of the invention as presently claimed and that disclosed by the cited '863 publication, attention is directed to the attached Declaration of Mr. Masaaki Fukuda, one of the inventors in the subject application. More particularly, the Declaration shows powder X-ray diffraction analysis of the sintered bodies according to the presently claimed invention and those of the Example of the '863 publication.

Specifically, Experiment 1 of the Declaration shows the powder X-ray diffraction spectra for the sintered body of Example 3 of the subject specification and for the sintered body of sample No. 3 in the Example of the cited '863 publication. A comparison of the X-ray diffraction spectra reveals that the diffraction angle of the diffraction peak of the main component is different between the sintered body of the Example of the '863 publication and the sintered body obtained by the method of the presently claimed invention. This difference in the diffraction angle of the diffraction peak shows that the crystal structures

of the sintered bodies are different from each other.

In addition, it is clear from the measurement of the bending strength, coefficient of thermal expansion, and thermal decomposition resistance obtained in Experiment 1 of the Declaration that the sintered body of Example 3 in the subject specification and the sintered body of sample No. 3 in the Example of the '863 publication are remarkably different in terms of their physical properties. In particular, the bending strength and thermal decomposition resistance are significantly different. Thus, from this portion of the Declaration, it can be concluded that the sintered bodies are completely different from each other.

In summary, and as discussed above, when the proportion of Al_2TiO_5 and MgTi of the sintered body sample No. 3 in the Example of the '863 publication is calculated based on the raw material composition, the value of x for the composition formula recited in claim 1 of the subject application is 0.058. It is to be specifically emphasized that this value is below the range specified in claim 1 of the present application. Further, a determination of the crystal structure by powder X-ray diffraction analysis confirms that the crystal structures are different between the sintered body sample No. 3 in the Example of the '863 publication and the sintered body of aluminum magnesium titanate according to the present invention, and further that the physical properties are completely different. Therefore, it is submitted that the sintered body of aluminum magnesium titanate as

defined in claim 5 patentably distinguishes over the teachings of the cited '863 Japanese patent publication.

For the reasons stated above, withdrawal of the rejection under 35 U.S.C. §103(a) and allowance of claim 5 over the cited patent publication are respectfully requested.

Claims 1-5 were rejected under 35 USC §103(a) as being unpatentable over the U.S. patent publication 2003/0015829 to Fukuda et al in view of either of the patents to Kameda or Oda et al. Reconsideration of this rejection in view of the following comments and enclosed documents is respectfully requested.

With regard to this rejection, it is to be noted that the publication to Fukuda et al is assigned to the same assignee as the subject application and that the subject application has an effective filing date prior to the publication date of the Fukuda et al publication. In particular, the publication to Fukuda apparently has a U.S. filing date of November 6, 2001, and a publication date of July 23, 2003. The subject application has a PCT filing date of October 9, 2003, and a priority date for Japanese patent application No. 2002-319934 of November 1, 2002, prior to the above publication date.

In order to perfect applicants' claim for priority to the above-mentioned Japanese patent application, enclosed is a verified translation of the priority application. Since the

translation supports the presently claimed invention, it is submitted that subject application is entitled to its priority date of November 1, 2002.

A recent amendment to 35 USC §103(c) became effective as to any application filed after November 29, 1999. This amendment provides that prior art effective under the provisions of 35 USC §102(e), that is, a U.S. patent having a issue date subsequent to the filing date of the subject application, or a published U.S. patent application having an earlier filing date, is no longer effective prior art if the two have the same assignee. Since the Fukuda et al publication and the subject application are assigned to the same assignee and the basis for citation of the patent would be 35 USC §102(e) for the Fukuda et al publication, the above provisions of §103(c) would apply. Thus, the cited Fukuda et al publication has been removed as an effective reference and the rejection has been obviated.

For the reasons stated above, withdrawal of the rejection under 35 U.S.C. §103(a) and allowance of claims 1-5 over the cited publications are respectfully requested.

Claims 1-5 were rejected under 35 USC §103(a) as being unpatentable over the '659 Japanese patent publication in view of either of the patents to Kameda or Oda et al. In making this rejection, it was asserted that the '659 publication teaches adding 1-15 parts by weight alkali feldspar to an aluminum titanate composition. While it was acknowledged

that this publication does not teach the addition of a magnesium component, it was asserted that this deficiency was supplied by either of the cited patents to Kameda and Oda et al. Reconsideration of this rejection in view of the following comments is respectfully requested.

It is submitted that the '659 Japanese patent publication and the patents to Kameda and Oda et al., whether taken singly or in combination, do not teach or suggest the presently claimed invention. More particularly, the '659 publication discloses a method for preparing a sintered body of aluminum titanate by sintering a product formed from a raw material mixture which is obtained by adding 1 to 15 parts by weight of alkali feldspar to 100 parts by weight of a mixture of TiO_2 and Al_2O_3 . The cited publication further discloses that the addition of alkali feldspar makes it possible to obtain a sintered body of aluminum titanate having, not only high mechanical strength and low expansion coefficient, but also excellent decomposition resistance and refractory properties.

However, it is to be specifically noted that the sintered body according to the '659 publication is a sintered body of aluminum titanate. In distinct contrast, the sintered body of the presently claimed invention is a sintered body of aluminum magnesium titanate. Thus, it is submitted that the sintered body according to the publication and the sintered bodies of the presently claimed invention are completely different as was clearly demonstrated by the X-ray diffraction spectra obtained in Experiment 1 of the Declaration.

Sintered bodies of aluminum magnesium titanate according to the presently claimed invention exhibit high mechanical strength and excellent resistance to thermal decomposition, while maintaining the low thermal expansion of aluminum magnesium titanate, by sintering a product formed from a raw material mixture comprising alkali feldspar and a mixture of a Mg-containing component, Al-containing component and Ti-containing component, such that aluminum magnesium titanate is formed. The sintered body obtained can be stably used at high temperatures ranging from 800°C to 1280°C, at which prior-art sintered bodies of aluminum magnesium titanate cannot be continuously used for long periods of time, and also can be used at high temperatures of not less than 1500°C, at which magnesium titanate is conventionally not used.

It is submitted that one of ordinary skill in the art would not be led to prepare sintered bodies of aluminum magnesium titanate, having the above-mentioned excellent properties as disclosed in the present application, from the teachings of the '659 publication. Among other things, this publication merely discloses a sintered body of aluminum titanate, which is completely different from the sintered body of the presently claimed invention.

In the subject rejection, the Kameda patent was cited as disclosing the addition of MgO to a sintered body of aluminum titanate, thereby increasing the strength of the aluminum titanate body. The cited Oda et al patent also was asserted to disclose adding a magnesium component to aluminum titanate, thereby improving the heat resistance and strength thereof.

From these teachings, it was concluded in the rejection that a person skilled in the art easily would be led to include a Mg-containing component in the aluminum titanate composition according to the '659 publication.

Although the Kameda patent discloses providing a high strength sintered body by adding MgO to a sintered body of aluminum titanate, the patent nowhere discloses the necessity of preparing a sintered body of aluminum magnesium titanate in the presence of alkali feldspar. More specifically, the Kameda patent merely discloses a method for sintering a raw material comprising 1 to 10% by weight of magnesium oxide, 0.5 to 10% by weight of silicon oxide, and aluminum titanate as a balance.

By using of a raw material having a high content of TiO_2 , aluminum magnesium titanate may be slightly formed. However, no alkali feldspar is used according to the publication and further the sintered body of aluminum titanate is prepared in the presence of silicon oxide. In these important respects, the method according to the Kameda patent is clearly different from the method of as defined by claim 1 of the present application.

More specifically, the subject specification discloses at page 8, lines 5 to 8 that alkali feldspar that is used according to the concepts of the invention has a low melting point and is effective for promoting the sintering of aluminum magnesium titanate. When preparing aluminum magnesium titanate using such alkali feldspar with a low melting point, as disclosed

on page 9, line 5, to page 10, line 22 in the subject specification, the Si component contained in the alkali feldspar dissolves into the aluminum magnesium titanate crystal lattice. Si and Mg then make pairs to replace the neighboring two Al atoms, thereby obtaining a stable crystal structure. As a result, the resultant body has a noticeably improved resistance to thermal decomposition.

In distinct contrast, the method according to the Kameda patent uses silicon oxide and magnesium oxide at the same time. Since the melting point of silicon oxide is about 1723°C, the silicon oxide does not melt at the formation temperature of aluminum titanate, which is about 1400°C. As a consequence, Si does not dissolve into the aluminum titanate crystal to separate out from the crystal system as SiO₂. Therefore, the effect of stabilizing the crystal structure is not achieved, as it is in the case of adding alkali feldspar. As a result, the sintered body obtained in accordance with the teachings of the Kameda patent is greatly inferior to the sintered body obtained by the method of the presently claimed invention.

In support of the above distinction, Experiment 2 of the attached Declaration shows test results of the thermal decomposition resistance of the sintered body obtained in Example 4 of the present specification and of sintered bodies obtained (a) using a raw material prepared by adding alkali feldspar to a raw material for the formation of aluminum titanate or (b) using a raw material prepared by adding MgO and SiO₂ to a raw material for the formation of aluminum titanate.

As can be observed from the test results set forth in the Declaration, the sintered body obtained using a raw material prepared by adding alkali feldspar to a raw material for the formation of aluminum titanate according to the '659 publication, when held in air at high temperatures, thermally decomposes almost completely in extremely short periods of about 30 hours or less. The sintered body according to the Kameda patent which is obtained from a raw material where silicon oxide and magnesium oxide are added somewhat extends the period in which the body completely decomposes when the raw material has a high TiO_2 content (samples E-3-1 and E-3-2), but the body still completely decomposes in a period as short as about 80 hours.

In distinct contrast, the sintered body obtained by the method of the present claimed invention, after being held in air at 1100°C for 400 hours, exhibits excellent resistance to thermal decomposition, and maintains a high residual aluminum magnesium titanate percentage, i.e., 95% or higher. In other words, the resistance to thermal decomposition of the sintered body obtained by the method of the presently claimed invention is incomparably higher than that of the sintered bodies obtained by the methods disclosed in the '659 publication and the Kameda patent.

In summary and as described above, the resistance to thermal decomposition is hardly improved even by the addition of alkali feldspar to aluminum titanate. Moreover, the sintered body according to the Kameda patent, which is obtained from a raw material prepared by

adding silicon oxide and magnesium oxide, shows, depending on the composition, an improved resistance to thermal decomposition, but the effect of improving the resistance to thermal decomposition is extremely slight compared with that demonstrated by a sintered body obtained by the method of the presently claimed invention.

The reason for such a remarkable difference between the sintered bodies according to the Kameda patent and those according to the presently claimed invention is not clear, but may possibly be attributed to the following explanation. Specifically, it is believed that the sintered body of aluminum magnesium titanate blended with alkali feldspar during the production process shows the effect of stabilizing the crystal structure due to the presence of both Si and Mg, as described above. However, such an effect is hardly demonstrated by the sintered body of aluminum titanate even when alkali feldspar is added. In addition, according to the method of the Kameda patent in which silicon oxide and magnesium oxide are used, Si does not dissolve into the aluminum titanate crystal to separate out from the system as SiO_2 . Therefore, the effect of stabilizing the crystal structure is not demonstrated and, as a result, the effect of improving the resistance to thermal decomposition is very slight.

In any regard, the resistance to thermal decomposition is barely improved when alkali feldspar is added to aluminum titanate. Also, in a sintered body obtained by the method using silicon oxide and magnesium oxide, resistance to thermal decomposition is only slightly improved.

Thus, it would not be easily envisaged by a person skilled in the art, even considering the disclosures of the '659 publication and the Kameda patent taken in combination, that a sintered body of aluminum magnesium titanate with excellent resistance to thermal decomposition could be obtained from a raw material prepared by adding a specific amount of alkali feldspar to the raw material for the production of aluminum magnesium titanate.

It is submitted that the cited patent to Oda et al does not supply the above noted teaching deficiencies. In particular, the Oda et al patent discloses a low-expansion ceramic comprising MgO , Al_2O_3 and TiO_2 , whose crystal phase has magnesium-aluminum-titanate as a major component. It is also disclosed that this ceramic has excellent heat resistance, thermal shock resistance, etc.

However, the Oda et al patent merely discloses, for example in lines 29 to 37 of column 4 thereof, improving the strength and the like due to the presence of at least one component selected from the group consisting of rutile, spinel and corundum. The Oda et al patent nowhere discloses obtaining a sintered body of aluminum magnesium titanate with high mechanical strength and excellent resistance to thermal decomposition by adding a specific amount of alkali feldspar to the raw material during the production of aluminum magnesium titanate. Also as described above, the '659 publication merely discloses the use of alkali feldspar in the method of producing a sintered body of aluminum titanate, and does not teach any effect demonstrated by the addition of alkali feldspar during the production of a sintered

body of aluminum magnesium titanate, which is different from a sintered body of aluminum titanate.

Accordingly, it is submitted that one of ordinary skill in the art would not easily have led to the subject matter defined in present claims 1 to 5 from a combination of the disclosures of the '659 publication and the patent to Oda et al. For the reasons discussed above, claims 1 to 5 of the present application patentably distinguish over the '659 publication in view of one of the Kameda or Oda et al patents.

For the reasons stated above, withdrawal of the rejection under 35 U.S.C. §103(a) and allowance of claims 1 through 5 over the cited patent publications are respectfully requested.

Claims 1-5 were provisionally rejected over claims 1-3 of copending application Ser. No. 10/169,728 in view of either of the above patents to Kameda or Oda et al, based on the judicially created doctrine of obviousness type double patenting. In making this rejection, it was asserted that, although the claims of this application and the cited copending applications are not identical, they are obvious over the other and thus are not patentably distinct. Reconsideration of this rejection in view of the following comments is respectfully requested.

The cited application discloses a method for preparing a sintered body of aluminum titanate by sintering a formed product from a raw material mixture prepared by adding 1 to 15

parts by weight of alkali feldspar to 100 parts by weight of a mixture of TiO_2 and Al_2O_3 , as in the above cited '659 Japanese patent publication. As such, the sintered body obtained by the method defined in claims 1 to 3 of the cited copending application is a sintered body of aluminum titanate, which is completely different from the sintered body of aluminum magnesium titanate of the presently claimed invention.

In addition, as discussed above, although the Kameda patent discloses obtaining a high strength sintered body by adding silicon oxide and magnesium oxide at the same time to a sintered body of aluminum titanate, the resistance to thermal decomposition of the resultant sintered body is greatly inferior to that of the sintered body of the presently claimed invention. The Oda et al patent discloses a low-expansion ceramic comprising a specific amount of MgO , Al_2O_3 and TiO_2 , whose crystal phase has magnesium-aluminum-titanate as a major component. However, the patent nowhere discloses obtaining a sintered body of aluminum magnesium titanate with high mechanical strength and excellent resistance to thermal decomposition by adding a specific amount of alkali feldspar to the raw material during the production of aluminum magnesium titanate.

Accordingly, it is submitted that the subject matter defined in claims 1 to 5 directed to sintered bodies of aluminum magnesium titanate or processes for producing the same are not obvious over the cited copending application even considering the disclosures of Kameda or Oda et al patents. Accordingly, withdrawal of the provisional rejection and allowance of claims

1 through 5 over the cited application and publication are respectfully requested.

Claims 1-5 were provisionally rejected over claims 1-5 of copending application Ser. No. 10/511,272 in view of either of the above patents to Kameda or Oda et al, based on the judicially created doctrine of obviousness type double patenting. In making this rejection, it was again asserted that, although the claims of this application and the cited copending applications are not identical, they are obvious over the other and thus are not patentably distinct. Reconsideration of this rejection in view of the following comments is respectfully requested.

The cited copending application relates to a raw material composition for a sintered body of aluminum titanate, a process for preparing a sintered body of aluminum titanate, and a sintered body of aluminum titanate. Claim 1 thereof discloses a raw material composition for a sintered body of aluminum titanate prepared by adding alkali feldspar and a Mg-containing component to a mixture of TiO_2 and Al_2O_3 .

However, as described above, the sintered body of aluminum magnesium titanate according to the presently claimed invention is a solid solution of aluminum titanate represented by Al_2TiO_5 and magnesium titanate represented by MgTi_2O_5 , which can be rewritten by the formula: $(\text{Al}_2\text{TiO}_5)_{1-x} (\text{MgTi}_2\text{O}_5)_x$. Claim 1 of the copending application recites a raw material composition prepared by adding alkali feldspar and MgO to a raw material for the production of a sintered body of aluminum titanate consisting of 40 to 50 mol% of TiO_2 and

60 to 50 mol% of Al_2O_3 . The use of such a raw material in which the content of TiO_2 is at most 50 mol% does not provide magnesium titanate represented by MgTi_2O_5 because all of the TiO_2 is used in the formation of Al_2TiO_5 , and thus there is insufficient TiO_2 for the formation of magnesium titanate. Therefore, aluminum magnesium titanate, which is a solid solution of aluminum titanate and magnesium titanate, is not formed even by using a raw material composition comprising alkali feldspar and a Mg-containing component as disclosed in cited copending application.

In summary, the cited copending application relates to a sintered body of aluminum titanate which is clearly distinguishable from the aluminum magnesium titanate of the presently claimed invention. Furthermore, as is clear from the X-ray diffraction spectra obtained in Experiment 1 of the Declaration, aluminum magnesium titanate and aluminum titanate are different in the crystal structure and are clearly distinguishable. The patents to Kameda and Oda et al do not supply these teaching deficiencies for the reasons set forth in the immediately prior rejection. Accordingly, withdrawal of the provisional rejection and allowance of claims 1 through 5 over the cited application and cited publication are respectfully requested.

In view of the foregoing, it is submitted that the subject application is now in condition for allowance and early notice to that effect is earnestly solicited.

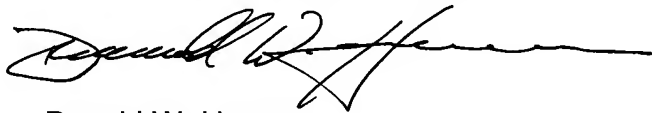
In the event this paper is not timely filed, the undersigned hereby petitions for an

Serial No. 10/530,476
OA dated February 16, 2006
Request dated July 31, 2006

appropriate extension of time. The fee for this extension may be charged to Deposit Account No. 01-2340, along with any other additional fees which may be required with respect to this paper.

Respectfully submitted,

ARMSTRONG, KRATZ, QUINTOS, HANSON & BROOKS, LLP



Donald W. Hanson
Attorney for Applicants
Reg. No. 27,133

Atty. Docket No. 050199
Suite 1000, 1725 K Street, N.W.
Washington, D.C. 20006
(202) 659-2930
DWH/nk



23850

PATENT TRADEMARK OFFICE

Enclosures: Declaration; Verified Translation of JP 2002-319934; Translation of H04-280863



Japanese Patent Office (JP)
UNEXAMINED PATENT PUBLICATION (A)

(11) Unexamined Patent Publication

No.: H04-280863

(43) Date of Publication:

October 6, 1992

(51) Int. Cl.⁵: FI
C04B 35/46 Z 7310-4G
F02F 1/24 C 7616-3G

Examination not requested
Number of Claims: 4 (total 4 pages)

(21) Patent Application
No.: H03-65682

(22) Filing Date:
March 6, 1991

Applicant: 000125934

ISUZU CERAMICS RESEARCH

INSTITUTE Co., Ltd.

8 Tsuchidana, Fujisawa-shi,
Kanagawa, Japan

(72) Inventor: Shogo SUZUKI

5-5-11 Minamirinkan,

Yamato-shi, Kanagawa, Japan

(74) Attorney: Minoru TSUJI

(54) [Title of the invention]

High strength and low thermal-expansion ceramic

(57) [Abstract]

[Object]

To provide a high strength and low thermal-expansion ceramic.

[Constituents of the invention]

A high strength and low thermal-expansion ceramic is prepared by adding sumecton SA, which is an inorganic polymer, to aluminum titanate.

Sample No.	Al ₂ O ₃ 1 TiO ₂ 1	Additive	Binder	Coefficient of thermal expansion ×10 ⁻⁶ /C°	Strength g/mm ²
1	90 wt%	TiO ₂ 5 wt%	Clay A 5 wt%	1.5	3
2	90 wt%	TiO ₂ 5 wt%	Clay B 5 wt%	1.0	2
3 (present invention)	90 wt%	TiO ₂ 5 wt%	Sumecton SA 5 wt%	1.0	3.5
4 (present invention)	90 wt%	TiO ₂ 5 wt%	Sumecton SA 5 wt%	1.3	4.5

[Claims]

[Claim 1] A high strength and low thermal-expansion ceramic, which is characterized by adding, as an additive, sumecton that is an inorganic polymer to aluminum titanate.

5 [Claim 2] The high strength and low thermal-expansion ceramic according to Claim 1, which is characterized by adding, as an additive, sumecton in which sodium ions have been replaced by ammonium ions by ion exchange.

10 [Claim 3] The high strength and low thermal-expansion ceramic according to Claim 1, which is characterized by comprising, in addition to sumecton, at least one member of MgO, ZrO₂, Y₂O₃, SiO₂ and zircon.

[Claim 4] The high strength and low thermal-expansion ceramic according to Claim 1, wherein the content of K₂O as an impurity is not more than 0.01 wt%.

15 [Detailed description of the present invention]

[0001]

[Technical Field to Which the Invention Pertains]

The present invention relates to a high strength and low thermal-expansion ceramic.

20 [0002]

[Prior Art]

Engine parts such as inlet ports, outlet ports, cylinders, pistons and the like are subjected to high temperatures and are required to have a certain degree of strength. Moreover, to attain a certain level of engine performance requires seal against leakage at the inlet port and outlet port and seal between the cylinder and piston and/or between a cylinder liner and cylinder head. In addition, high thermal shock resistance is also important. Thus, materials for parts requiring high temperature resistance and seal as described above must have a low coefficient of thermal expansion.

30 [0003]

For example, aluminum titanate can be mentioned as a material having such properties. Aluminum titanate has a high melting point of 1860°C as well as low coefficient of thermal expansion, and thus is suitable for use under high temperature conditions. Aluminum

titanate, however, is disadvantageous in that its strength is low and it is likely to decompose.

[0004]

Heretofore, in order to improve the disadvantageous properties
5 of aluminum titanate and put it into practical use in mechanical parts
such as engines and the like, ZrO_2 , MgO , SiO_2 etc., have been used,
in addition to aluminum oxide and titanium oxide, so that decomposition
at high temperatures is inhibited, strength is improved, coefficient
of thermal expansion is lowered and hysteresis is eliminated. With
10 the addition of such additives, aluminum titanate ensures the adequate
physical properties of ceramic. However, forming aluminum titanate
into the shape of practically-used parts requires further addition
of a binder. Heretofore, a clay having the formulation shown in Fig.
1 has been generally used as a conventionally-used binder.

15 [0005]

[Problem to be Solved by the Invention]

However, when such a clay is used as a binder in a slip casting
method, there are changes in slip properties, mold releasability,
drying shrinkage degree and heating shrinkage degree. Moreover, clay
20 is also problematic in accelerating the decomposition of aluminum
titanate at high temperatures due to the large amount of Al_2O_3 contained
therein. Accordingly, clay poses problems when used for production
of precision parts such as outlet ports of engine parts and the like.

[0006]

25 The present invention was accomplished in view of the drawbacks
of the prior art described above. More specifically, the invention
provides a high strength and low thermal-expansion ceramic with the
use of an inorganic polymer as a binder during preparation of aluminum
titanate.

30 [0007]

[Means for Solving the Problem]

In order to solve the above problems, the invention provides
a manner for adding sumecton that is an inorganic polymer as an additive
(binder) to aluminum titanate.

35 [0008]

[Action]

The addition of sumecton that is an inorganic polymer to aluminum titanate can provide a high strength and low thermal-expansion ceramic.

5 [0009]

[Examples]

The following description is given to explain Examples of the invention. Examples used, as a binder, sumecton SA that is a synthetic inorganic polymer (trade name, product of Kunimine Industries Co.,
10 Ltd.). Sumecton SA is represented by Formula shown in Fig. 2. The chemical analysis values are as shown Fig. 3. The numerical values in the figures are expressed in wt%. The content of K_2O as an impurity is 0.01 wt% or lower in this sumecton. The examination results are shown in Figs. 4 and 5.

15 [0010]

As is clear from Fig. 4, samples Nos. 3 and 4 prepared using sumecton SA as a binder exhibit higher strength compared to samples Nos. 1 and 2 prepared using conventionally-used binders; although there is no noticeable difference in the coefficients of the thermal
20 expansion therebetween. When this experiment was performed using sumecton SA in which sodium ions were replaced by ammonium ions by ion exchange, the similar results were obtained. Moreover, when this experiment was performed using aluminum titanate further comprising at least one member of MgO , ZrO_2 , Y_2O_3 , SiO_2 and zircon in addition
25 to sumecton, the similar results were obtained.

[0011]

Subsequently, the inhibitory effect on the decomposition of aluminum titanate maintained at $110^\circ C$ for 100 hours was measured. The measurement results are shown in Fig. 5. As is clear from Fig. 5,
30 the binder used in the Examples shows an extremely low decomposition level of alumina titanate compared to the conventionally-used binders (samples Nos. 1 and 2). This is because the Al_2O_3 content of the binder used in Examples is smaller than that of the conventionally-used binders and because the composition of the binder is extremely stable
35 due to being a synthetic material. The size of the particles is

submicron and thus the particles are uniformly distributed between the particles of aluminum titanate to effectively functions as a binder and decomposition inhibitor. When the clay is used in a weight of, for example, 5 wt%, the impurity level, i.e., K_2O content, is remarkably
5 reduced, and therefore, the use of clay as a binder possibly improves high temperature properties.

[0012]

[Effect of the Invention]

As described above in detail, the invention has provided a high
10 strength and low thermal expansion ceramic by the addition of sumecton that is an inorganic polymer serving as a binder. Accordingly, the invention achieves an excellent effect that high-precision parts are manufactured.

15 [Brief Descriptions of the Drawings]

[Fig. 1] Fig. 1 shows a clay composition.

[Fig. 2] Fig. 2 shows the chemical formula of sumecton SA.

[Fig. 3] Fig. 3 shows chemical analysis values of sumecton SA.

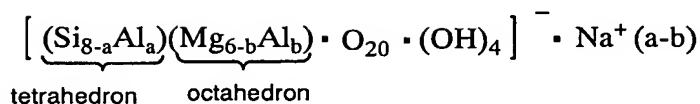
[Fig. 4] Fig. 4 shows comparison results between the invention and
20 prior art.

[Fig. 5] Fig. 5 shows comparison results of the decomposition level of binders of the invention and of the prior art.

[Fig. 1]

Composition of clay	
SiO ₂	49.3 wt%
Al ₂ O ₃	33.5 wt%
Fe ₂ O ₃	1.4 wt%
TiO ₂	0.8 wt%
CaO	0.2 wt%
MgO	0.2 wt%
K ₂ O	0.7 wt%
Na ₂ O	0.1 wt%
Ig Loss	13.8 wt%

[Fig. 2]



5

wherein $a-b > 0$

[Fig. 3]

SiO ₂	53 wt%
Al ₂ O ₃	5 wt%
MgO	30 wt%
Other ingredients	12 wt%

[Fig. 4]

Sample No.	Al ₂ O ₃ 1 TiO ₂ 1	Additive	Binder	Coefficient of thermal expansion ×10 ⁻⁶ /C°	Strength g/mm ²
1	90 wt%	TiO ₂ 5 wt%	Clay A 5 wt%	1.5	3
2	90 wt%	TiO ₂ 5 wt%	Clay B 5 wt%	1.0	2
3 (present invention)	90 wt%	TiO ₂ 5 wt%	Sumecton SA 5 wt%	1.0	3.5
4 (present invention)	90 wt%	TiO ₂ 5 wt%	Sumecton SA 5 wt%	1.3	4.5

10

[Fig. 5]

Sample No.	Decomposition level at 1100°C for 100 hours
1	5%
2	7%
3 (present invention)	0.5%
4 (present invention)	0.8%